Failure of a Carbon Fiber–Reinforced Polymer Implant Used for Transforaminal Lumbar Interbody Fusion

Zeeshan Sardar[1] Peter Jarzem[1]

[1] McGill University Health Centre, Montreal, Quebec, Canada

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Address for correspondence Zeeshan Sardar, MDCM, MSc, Orthopaedic Residency Training Program, Shriners Hospital for Children, 1529 Cedar Avenue, Montreal, Quebec, Canada H3G 1A6 (e-mail: zeeshan.sardar@mail.mcgill.ca).

Abstract

Lumbar interbody fusion is a common procedure owing to the high prevalence of degenerative spinal disorders. During such procedures, carbon fiber–reinforced polymer (CFRP) cages are frequently utilized to fill the void created between adjacent vertebral bodies, to provide mechanical stability, and to carry graft material. Failure of such implants can lead to significant morbidity. We discuss the possible causes leading to the failure of a CFRP cage in a patient with rheumatoid arthritis. Review of a 49-year-old woman who underwent revision anterior lumbar interbody fusion 2 years after posterior instrumentation and transforaminal lumbar interbody fusion at L4–L5 and L5–S1. The patient developed pseudarthrosis at the two previously fused levels with failure of the posterior instrumentation. Revision surgery reveled failure with fragmentation of the CFRP cage at the L5–S1 level. CFRP implants can break if mechanical instability or nonunion occurs in the spinal segments, thus emphasizing the need for optimizing medical management and meticulous surgical technique in achieving stability.

Keywords
- carbon fiber–reinforced polymer
- cage failure
- nonunion
- rheumatoid arthritis

Lumbar interbody fusion procedures, such as posterior lumbar interbody fusion and transforaminal lumbar interbody fusion (TLIF), are performed commonly nowadays due to the high prevalence of degenerative spinal conditions. These procedures involve removing the disk material and cartilaginous end plates from the involved intervertebral disk space and filling up the void with a spacer to maintain disk height and to decompress the neural foramina. Choices for the spacer include structural allograft, structural autograft, or synthetic cages that can be packaged with graft material. Such synthetic cages are meant to offer immediate rigid structural support while carrying bone graft that would result in osseous fusion between the two vertebral bodies.[1–3] One such cage used in TLIF procedures is made of carbon fiber–reinforced polymer (CFRP; Leopard, Depuy, Raynham, MA, USA) and has two chambers for insertion of bone graft. It has a modulus of elasticity approximating that of cortical bone and has four tantalum beads to visualize cage position on radiographs. Because of the ability to carry autologous bone graft, high rates of fusion with the CFRP cages have been reported in literature without much implant-related complications.[1,3–6] To our knowledge, there has been only one reported case of CFRP cage failure in the literature.[7] We report here another case of a CFRP cage failure.

Case Report

A 49-year-old nonsmoking woman with a history of rheumatoid arthritis underwent surgery at another institution for degenerative spondylolisthesis at L4–L5 and L5–S1 in January 2009. The procedure entailed posterior instrumentation and TLIF at L4–L5 and L5–S1 with 8-mm CFRP cages (Leopard, Depuy) using local autograft. The patient was not braced at any point. Her symptoms of low back pain continued postsurgery. She had been off work for 3 years and presented to our clinic in March 2011 (►**Fig. 1**) for evaluation of persistent back pain radiating down to both legs with difficulty walking

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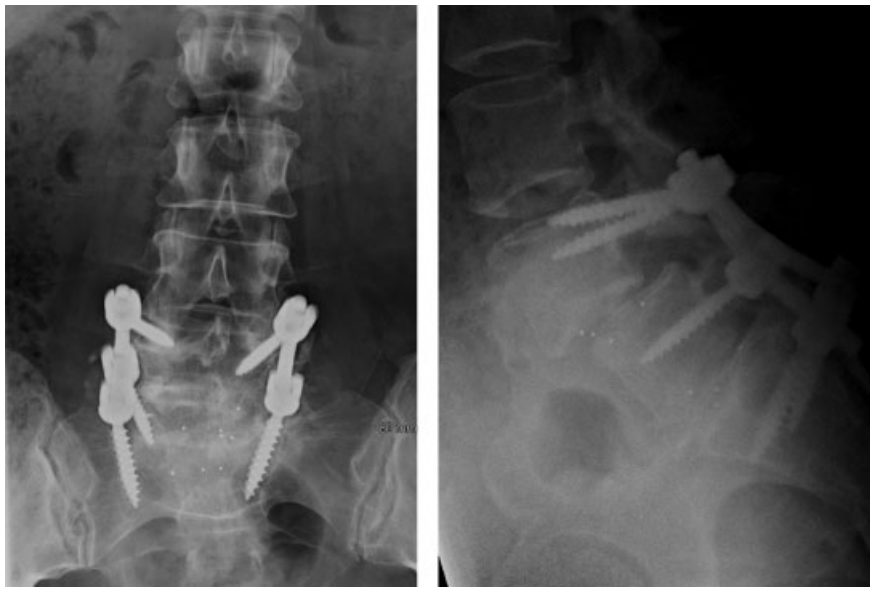

Fig. 1 Anteroposterior and lateral X-rays done before the revision surgery (March 2011).

Table 1 List of medications in March 2011

Etanercept (stopped 2 wk prior to revision surgery)
Methotrexate (stopped 1 wk prior to revision surgery)
Hydromorphone
Meloxicam (stopped 2 d prior to revision surgery)
Folic acid
Carbamazepine
Hydroxychloroquine
Meperidine
Pantoprazole

short distances. At this time she had a body mass index (BMI) of 23.4 and was being actively treated for rheumatoid arthritis (►**Table 1**). Computed tomography scan in June 2011 showed loosening of bilateral L4 and S1 pedicle screws with moderate spinal canal and foraminal stenosis at L4–L5, and loss of disk space height at the L4–L5 level with no fusion between the vertebral bodies (►**Fig. 2**). The workup for infection, which included erythrocyte sedimentation rate, C-reactive protein. white blood cell count, and blood cultures, was negative.

The decision was made in conjunction with the patient to perform anterior lumbar interbody fusion at L4–L5 and L5–S1. We had also decided with the patient that if she remained symptomatic after the anterior stabilization, then she may have to undergo revision of the posterior instrumentation as a second stage. Intraoperatively, an L5–S1 diskectomy revealed cage fragments (►**Fig. 3**) that were immediately recognized at the time of diskotomy, permitting us to remove the cage in a piecemeal fashion without needing to break off pieces from the cage. At L4–L5, the cage was relatively intact and had to be broken apart before being removed. Once emptied, the disk spaces were then fitted with a titanium alloy spacer (SynCage, Synthes, Mississauga, Canada) at each level filled with iliac crest bone graft,

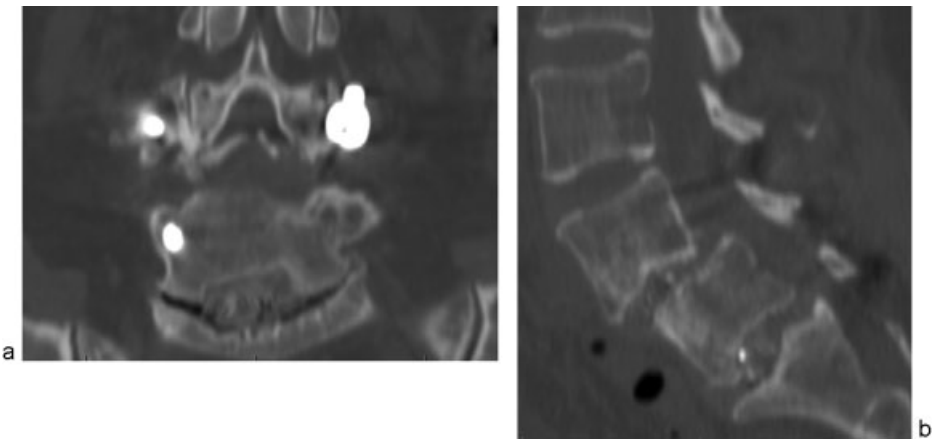

Fig. 2 Computed tomography scan done in June 2011 showing the pseudarthrosis in the (a) coronal and the (b) sagittal planes.

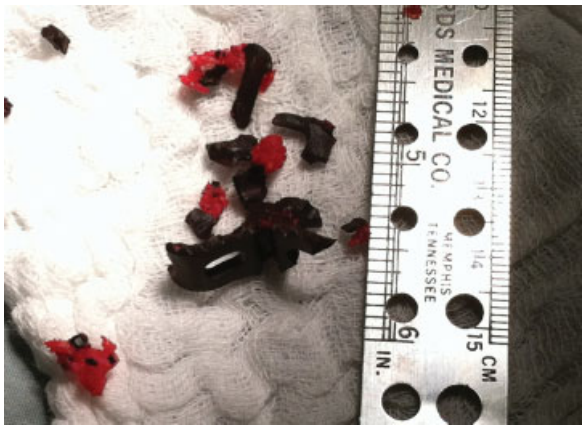

Fig. 3 Intraoperative pictures showing the broken cage pieces.

morcelized allograft, and DBX Demineralized Bone Matrix (Synthes). The patient recovered well from the surgery without any perioperative complications and had significant improvement in her symptoms at 4-month follow-up (►**Fig. 4**).

Discussion

This case study reports on a patient who underwent two-level lumbar interbody fusion and posterior instrumentation with continued back pain postoperatively due to pseudarthrosis at the involved levels, eventually leading to failure of the CFRP cage. This was treated by revision surgery providing anterior stabilization at the levels of the nonunion, thus resulting in improvement in the patient's symptoms. There has been no reported case to our knowledge of failure of the CFRP cage in situ after implantation. The only other case report of failure of a carbon fiber cage was caused by nonunion secondary to infection and showed that the surrounding connective tissue was black in portions owing to carbon particles.[7] However, in our case there was no gross discoloration of the surrounding tissues possibly because of the absence of an inflammatory or infectious process that might be needed to compromise the biostability of this product.[7,8] We suspect that in our case the failure was mainly due to mechanical instability caused by nonunion evident through loosening of the pedicle screws demonstrated on preoperative computed tomography. Nonunion is listed in the product monograph as one of the causes of cage failure and appears to be a common factor in this and the previous CFRP cage failure.[7,9] CFRP and polyether ether ketone cages have a modulus of elasticity closer to that of cortical bone and therefore have the advantage of possibly causing less stress shielding, less end plate subsidence, and better fusion rates when compares to titanium cages.[10,11] However, even though the CFRP cages provide initial stability,[11] they may not have enough stiffness to endure repetitive long-term motion in the face of a nonunion, hence leading to failure. This is why in the revision procedure we used a titanium cage to provide more stiffness and stability to the construct because instability was the major cause of failure in this case.

Noncentral positioning of the cage in the intervertebral space may also have been a factor leading to higher strain on the cage,[12] although we cannot confirm that as a cause in this particular case. The quality of bone in patients with rheumatoid arthritis is a factor in cage subsidence and failure, as has been suggested by Lam et al.[13] Additionally, the use of disease-modifying medications can impede bone formation

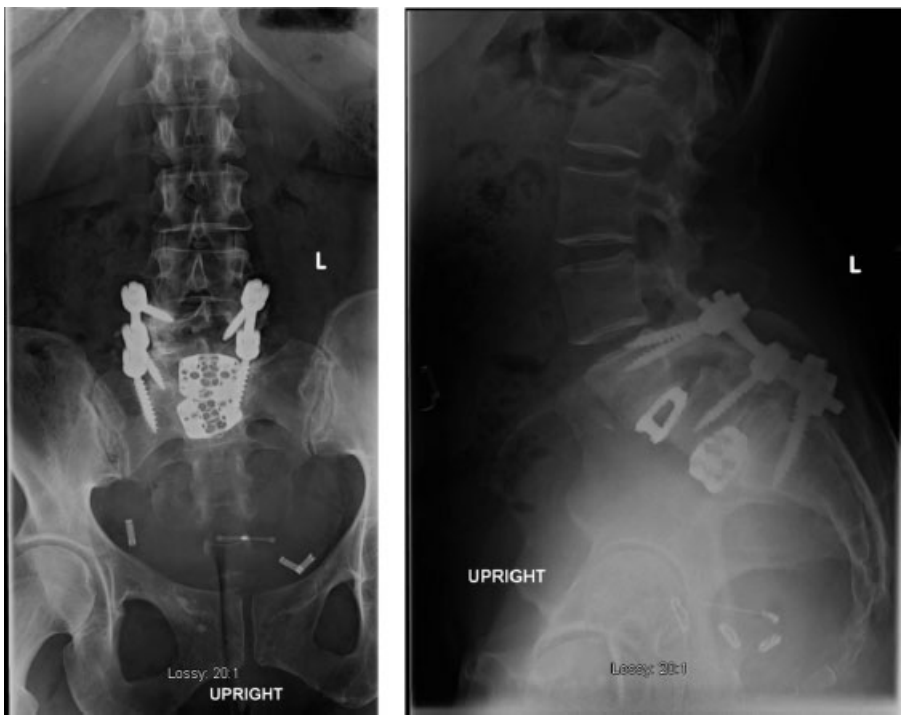

Fig. 4 Anteroposterior and lateral X-rays 4 months post–revision anterior surgery (April 2012).

and repair, predisposing to nonunion.[14–17] Patients with rheumatoid arthritis often have osteopenic bone that has been known to be related to spinal instrumentation failure.[18,19] Iliac crest bone graft is considered the gold standard bone graft in most lumbar interbody fusion cases; however, due to the potentially poor bone quality of this patient with rheumatoid arthritis on disease-modifying agents, we decided to add allograft augmented with demineralized bone matrix to the cages to provide more "normal"-quality bone.[20–24]

In conclusion, the failure of a CFRP cage in situ is a very rare occurrence, and these cages still remain an excellent option to fill the intervertebral void.[1,3–5] However, this case shows that CFRP implants can break if mechanical instability or nonunion occurs in the spinal segments and thus emphasizes the need for optimizing medical management and meticulous surgical technique in achieving stability.

Disclosures
Zeeshan Sardar, None
Peter Jarzem, None

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